US005861997A

United States Patent [19]

Takahashi

[11] Patent Number: 5,861,997

[45] Date of Patent: Jan. 19, 1999

[54] CATADIOPTRIC REDUCTION PROJECTION OPTICAL SYSTEM AND EXPOSURE APPARATUS HAVING THE SAME

[75] Inventor: Tomowaki Takahashi, Yokohama, Japan

[73] Assignee: Nikon Corporation, Tokyo, Japan

[21] Appl. No.: 515,631

[22] Filed: Aug. 16, 1995

[30] Foreign Application Priority Data

Aug. 23, 1994 [JP] Japan 6-198350

[51] Int. Cl.[6] G02R 27/00

[52] U.S. Cl. 359/727; 359/720

[58] Field of Search 359/70, 77

[56] References Cited

U.S. PATENT DOCUMENTS

4,953,960	9/1990	Williamson .	
5,089,913	2/1992	Singh	359/727
5,220,454	6/1993	Ichihara et al. .	
5,241,423	8/1993	Chiu et al.	359/727
5,402,267	3/1995	Fürter et al. .	

Primary Examiner—Georgia Y. Epps
Assistant Examiner—Thomas Robbins
Attorney, Agent, or Firm—Pennie & Edmonds

[57] ABSTRACT

A catadioptric projection optical system is provided, which can use a beam splitting optical system smaller in size than a conventional polarizing beam splitter, can set a long optical path from a concave reflecting mirror to an image plane, allows easy adjustment of the optical system, and has excellent imaging performance. A light beam from an object surface forms a first intermediate image through a refracting lens group. A light beam from the first intermediate image passes through a polarizing beam splitter and is reflected by a concave reflecting mirror to form a second intermediate image in the polarizing beam splitter. A light beam from the second intermediate image is reflected by the polarizing beam splitter means to form a final image on the image plane via a refracting lens group. The polarizing beam splitter means is arranged near the positions at which the intermediate images are formed.

14 Claims, 13 Drawing Sheets